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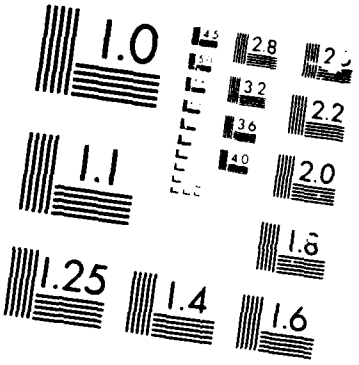
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# CENTRAL DENTAL HIGH-VACUUM (HIVAC) ORAL EVACUATION SYSTEMS

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May 1986

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USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, TX 78235-5301

## NOTICES

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The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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This report includes the minimum requirements for central dental high-vacuum (HIVAC) oral evacuation systems and associated centrally plumbed distribution networks for use in USAF dental health facilities. These specifications are interim until joint evaluations by the Dental Investigation Service and the Occupational and Environmental Health Laboratory establish standards for dental clinics.

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# CENTRAL DENTAL HIGH-VACUUM (HIVAC) ORAL EVACUATION SYSTEMS

## 1. INTRODUCTION

1.1 HIVAC System. The central dental high-vacuum (HIVAC) oral evacuation system is designed to build and sustain high vacuum pressures at very low air flow. Specifically, this system provides for safe removal of viscous fluids, suture material, hard and soft-tissue debris from surgical wound sites, without damage to normal tissue or dislodgement of freshly formed blood clots. Inlets to the central system are located in dental treatment rooms (DTRs) of all dental disciplines that create open soft-tissue surgical wounds in their treatment procedures. All inlets are connected to a central piping network that operates as a dry-type system, with individual separators and related hardware located in each using DTR. Clinical end items required for the clinical use of dental HIVAC system are not considered part of the distribution network since they are not the responsibility of the system and distribution network maintenance organization.

1.2 System Performance. The HIVAC system provides the same performance as the hospital surgical vacuum system used for hospital operating rooms. For dental clinics that are part of a composite health facility, the dental HIVAC service can be provided from the hospital surgical vacuum system or medical vacuum system.

1.3 Minimum Requirements. The guidelines provided are minimum requirements for safe, proficient, reliable, and cost-effective production and distribution of dental HIVAC systems essential to dental health-care delivery. The information provided is applicable to all HIVAC systems in new construction and system replacement projects. The information is intended to supplement and provide a basis for other design criteria, guide specifications, codes and specifically Air Force Regulation 88-50,"Criteria for Design and Construction of Air Force Health Facilities."

1.4 Safety. The system and distribution network for HIVAC service in free-standing dental facilities are not used in flammable anesthetizing gas locations, are not used to scavenge anesthetic or other flammable or nonflammable gases, and are not provided in inpatient areas. Therefore, the dental HIVAC system and distribution network are not within the jurisdiction of National Fire Protection Association Standard 99.

## 2. DEFINITIONS

2.1 Actual Cubic Feet Per Minute (ACFM). The unit volume of gas flow at operating pressure and temperature.

2.2 Clinical End Items. Devices that connect to the individual terminal inlet fixtures for clinical use of HIVAC service.

2.3 Facility Demand. The calculated maximum standard cubic feet per minute (SCFM) capacity for which the system is sized, based on the total number of DTR terminal inlets and the simultaneous use factor.

2.4 HIVAC Centrally Piped Distribution Network. All central plumbing, valves, monitors, terminal inlet fixtures, and other specified components for distribution of HIVAC service; originating with the terminal outlet fixture, and terminating at the point of connection to the HIVAC system.

2.5 HIVAC System. A central assembly of vacuum producers, receiver, switches, valves, and other electrical, mechanical, gas, and fluidic controls, components, and interconnections for the production of surgical vacuum service, and terminating at the point of connection to the HIVAC central distribution network.

2.6 Inches of Mercury (in. Hg). The unit of negative pressure or vacuum measurement.

2.7 Risers. Pipes connecting the terminal inlet fixtures to the trunk lines of the HIVAC distribution network.

2.8 Standard Cubic Feet Per Minute (SCFM). The unit volume of gas flow at standard pressure and temperature (one atmosphere; 20°C [68°F]).

2.9 Terminal Inlet Fixture. A quick connect/disconnect or threaded, valved device for connection of clinical end items to the HIVAC central plumbing.

2.10 Trunk Lines. Pipes of the HIVAC distribution network that connect risers to the HIVAC system.

## 3. REQUIREMENTS

3.1 Support. The HIVAC system and distribution network are intended to support the requirement for specialized surgical vacuum service to specified locations and shall not be used for any other purpose.

3.2 Distribution. HIVAC service shall be distributed by the following:

| Location | No. of Terminal Inlets |
|---|---|
| DTRs for oral surgery | One/DTR |
| DTRs for periodontia | One/DTR |
| DTRs for endodontia | One/DTR |
| Recovery room | One/Bed |

3.3 Facility Demand. The facility demand for the HIVAC system and distribution network shall be calculated as two SCFM for each DTR HIVAC terminal inlet fixture specified, multiplied by the appropriate simultaneous use factor selected from the following:

| No. of DTR Terminal Inlets | Use Factor |
|---|---|
| 1-6 | 1.0 |
| 7-10 | 0.8 |
| Over 10 | 0.6 |

NOTE: Recovery room terminal inlet fixtures are not used in facility demand calculations.

3.4 Vacuum Requirement. The HIVAC system and distribution network shall be capable of maintaining not less than 12-in. Hg vacuum pressure at the terminal most distant from the vacuum source when the calculated facility demand is drawn through the network by the system.

3.5 Components. All piping used for interconnections within the system shall be type "K," "L," or "M" ASTRONAUT B88 seamless copper tubing. All piping for the central distribution network shall be type "M" copper tubing. All fittings used for connecting copper tubing shall be wrought copper, brass, or bronze designed for brazed or soldered connection. All tubing joints shall be soft soldered (minimum 232.2°C [450°F] alloy). Component connections requiring threaded connections shall be installed by tinning the male pipe thread with soft solder, Teflon tape, or other suitable joint compound approved for vacuum plumbing joints.

3.6 Factory Representative. The installer shall furnish a factory-trained representative of the system manufacturer who shall inspect the system and distribution network installations; and who shall, after installation approval, assist in startup and testing, and in training of personnel responsible for system and network maintenance as elsewhere specified. The factory-trained representative shall not be required for the distribution network piping leak test prior to connection of the system.

3.7 HIVAC System.

3.7.1 The HIVAC system shall be supplied as a complete module or package with all components factory mounted on the system receiver, prewired and tested; delivered for four-point connection to vacuum input, vacuum output, electrical power, and remote control panel.

3.7.2 The HIVAC system shall contain, but not be limited to, the following major components:

- Vacuum pumps and motors
- Receiver
- Automatic pump lubricator
- Lubricant recovery device
- Lubricant reservoir
- Valves and interconnections
- Electrical controls and enclosure
- Remote control panel

3.7.3 The system shall be duplex, with two vacuum pumps (duplex) connected in parallel to a single receiver.

3.7.4 Each pump shall be sized to maintain the minimum vacuum specified while providing 100% of the calculated facility demand.

3.7.5 The pumps shall routinely and automatically start and operate alternately to maintain the calculated facility demand.

3.7.6 The pumps shall be equipped for automatic start of the second pump to maintain facility demand in the event of failure of one pump and to support a brief, unplanned, contingency demand on the system requiring both pumps to operate simultaneously.

3.7.7 The pumps shall be provided with means for remote manual selection of simultaneous operation to support known contingency demand (100% DTR inlet capability).

3.7.8 The pumps shall be electric motor powered, rotary, belt driven, oil lubricated, positive displacement, air cooled, sliding or hinged vane types.

3.7.9 Each pump shall be provided with an automatic oil feed device operating only during pump operation; an oil separator/recovery/recycling device; an oil reservoir, and a low oil level sensor.

3.7.10 Each pump and motor assembly shall be mounted on a separate subframe. Subframes shall be receiver mounted (tank-mount: horizontal receiver) with vibration isolators, and shall be provided with adjustable motor bases, cooling fan, V-belt drives, and belt guards.

3.7.11 All connections to pump inputs and outputs shall be flexible hose or flexible pipe to prevent vibration transmission.

3.7.12 The input side of each pump shall be provided with a manual gate valve for pump isolation and a directional flow (check) valve for backflow prevention.

3.7.13 Each pump output line shall be joined to a common air discharge line which shall vent to the atmosphere exterior to the facility. A drip leg with a manual and an automatic condensate valve shall be provided in the common discharge line as close as possible to the pump output connections. Pump output lines and common discharge vent shall be sized for minimum backpressure. The outdoor end of the vent shall be protected against entry of insects, vermin, debris, and precipitation without creating backpressure.

3.7.14 The system receiver shall be an American Society of Mechanical Engineers (ASME) Code constructed negative pressure vessel with a 0-30-in. Hg vacuum gage, a vacuum relief valve, and a manual condensate drain valve.

3.7.15 The system receiver size shall be considered as a characteristic of pump size and volume of the central distribution network piping and shall be sufficient to limit system cycling to not more than six starts/hour/pump while maintaining the calculated facility demand.

3.7.16 The electric motors shall be a standard National Electrical Manufacturers Association (NEMA) high efficiency, open drip-proof, 1800-rpm design with sealed bearings, rated 200, 230 or 460 VAC, 60 Hz, and three-phase.

3.7.17 The electric motor horsepower shall be adequate for the pump size required such that the rating for the motor is not exceeded to support the calculated facility demand.

3.7.18 Each motor shall be provided with a separate magnetic starter, circuit breaker, automatic low oil level switch and reset, manual on-off automatic selector switch, run indicator light, and run hour meter.

3.7.19 Other electrical controls shall include, but not be limited to, a low voltage transformer and circuit breaker sized to operate all system low voltage requirements; low voltage activated switching for remote selection of automatic alternation/simultaneous run/off conditions; lead-and-lag vacuum sensors and switches; a NEMA control panel, and a labeled remote control panel.

3.7.20 The remote control panel shall provide remote automatic alternation/simultaneous run/off switching of the HIVAC system; a run indicator light, and a cancelable audible, noncancelable visual alarm for failed pump (low negative pressure) warning.

3.7.21 Lead and lag-vacuum sensors and switches shall be located, adjusted, and connected to control pump drive motors according to the following nominal vacuum pressures:

| Switch Condition | Lead (first pump) | Lag (second pump) |
|---|---|---|
| On | 17 in. Hg | 15 in. Hg |
| Off | 19 in. Hg | 19 in. Hg |

3.7.22 The lead switch shall start and stop the pump selected by the automatic alternator. The lag switch shall start and stop the second pump for automatic simultaneous operation to support a contingency demand beyond the capability of one pump; and to maintain the calculated facility demand in the event of failure of the alternator selected pump.

3.7.23 A negative pressure sensor and switch assembly shall be installed at the output side of the system receiver. The assembly shall be adjusted and connected to serve as a failed pump monitor, activating the remote control panel alarm when system pressure falls to 15 in. Hg or less.

3.8 Centrally Piped Distribution Network.

3.8.1 Distribution network risers shall be sized to accommodate an input of not less than two SCFM through the served terminal input with the network maintaining not less than 12-in. Hg vacuum pressure.

3.8.2 Risers shall in no case be less than 1/4-inch inside diameter.

3.8.3 Distribution network trunk lines shall be proportionately sized along their lengths to accommodate an input of not less than two SCFM from each riser-connected terminal input.

3.8.4 Network trunk lines shall at no point be less than 1/2-inch nominal pipe size.

3.8.5 Distribution network piping shall be sized so that the network does not contribute more than 3-in. Hg pressure drop between the vacuum source connection and the most distant terminal input while supporting the calculated facility demand.

3.8.6 Terminal inlet fixtures shall be valved mechanisms conforming to the Diameter-Index Safety System (DISS) or other valved, quick-connect/disconnect type medical gas fixture not interchangeable with oxygen, nitrogen, nitrous oxide, or compressed air outlets.

3.8.7 Terminal inlet fixtures shall be appropriately labeled, flush, wall-mounted types located as specified.

3.9 Testing.

3.9.1 After installation of the distribution network piping and before connection to the vacuum source and terminal inlets, the piping shall be blown clear with dental compressed air or with cylindered dry nitrogen and capped for pressure testing.

3.9.2 All pipe joints shall be cleaned of excess flux for leak testing.

3.9.3 Before closing of walls and connection to the system, the distribution network shall be tested for leakage by pressurizing with compressed air or nitrogen to 50 psig and sealed. Allowing for temperature variance, at the end of 24 h, pressure loss shall not exceed 5 psig. If pressure does not hold, repairs shall be made and the network retested until the test criteria are satisfied.

3.9.4 After successful testing of the distribution network, the completed assembly of system and network shall be given a final installation leakage test. The system shall be started and run until shut down by the automatic controls, and vacuum in the network is in excess of 12 in.Hg. After 1 h and without restarting, vacuum loss in the system and network assembly shall not exceed 1.5 in.Hg. If test is failed, repairs shall be made and the test repeated until criteria are satisfied. After satisfactory leakage testing, all terminal inlets shall be tested individually to demonstrate a vacuum of 12 in.Hg, using a certified (certification traceable to the National Bureau of Standards) vacuum gage.

## 4. DOCUMENTATION

4.1 Instructions. The contractor shall supply two complete sets of the manufacturer's operating and maintenance instructions as specified in subparagraph 4.2 to the local maintenance organization who shall be responsible for system maintenance. Bound set covers shall be labeled with the system name, building number, contractor's name, and contract number.

4.2 General Information.

4.2.1 The manual shall include an overall description and purpose of the system or equipment. The function and purpose of each system component shall be described. The description shall include the intended use, capabilities, and limitations of the system or equipment. If the manual covers more than one model of a system or equipment, or systems or equipment modified by field change, a description of the differences shall be provided. Quick reference data shall be included and shall describe technical or design characteristics of the equipment. Examples of such data are:

- Descriptive (nameplate) data necessary to identify manufacturer, type, and model.

- Functional characteristics, such as: power and frequency requirements, voltage and amperage demands, outputs, and modes of operation.

- Rated outputs, such as: horsepower, cubic feet per minute, and revolutions per minute.

- Special characteristics, such as: operating temperatures, pressure, heat dissipation, and humidity.

4.2.2 A warning page, consisting of the more vital warnings extracted from those shown throughout the manual, shall be assembled. The warning page shall be placed on the inside cover or in front of the initial page(s) of the manual (See 4.2.7).

4.2.3 Operating instructions shall include routine and emergency procedures (manual and automatic) and safety precautions. Limits to be observed in the starting, operating, stopping, or shutting down of the equipment or system shall be provided. Adequate illustrative material shall be provided to identify and locate operating controls and indicating devices. The function of each operating control and indicating device shall be included. Emergency operating instructions shall include alternate procedures to be followed when normal operation is not possible because of emergency conditions, such as power or lubricating oil failure. Emergency operating instructions and procedures shall be located for quick and ready reference.

4.2.4 Preventive maintenance information shall be provided. Use of special tools, materials, and test equipment shall be specified, including model/type designation, as appropriate. The following procedures shall be stressed, if applicable:

4.2.4.1 Periodic cleaning and lubrication information, types of cleaning agents or lubricants required, recommended intervals, such as monthly, quarterly, semiannually, or hours of operation shall be provided. Application points and capacity (required amounts) shall be identified. Pictorial format for lubrication is desirable. Cleaning and lubrication required during repair, replacement, and reassembly shall also be covered. (See 4.2.6)

4.2.4.2 Instructions for inspection of equipment for damage and wear shall be included. Tabular or chart format is preferred and shall

include, where applicable, allowable service limits, wear, backlash, end play, length and depth of scoring, and balance. These instructions shall be sufficiently complete to serve as standards by which experienced technicians may determine when parts may be continued in use and when they must be replaced.

4.2.4.3 Instructions shall be included for verification of system performance. The location of test connections and the values expected at these points shall be included, preferably in illustrated form. Data shall include a list of equipment required to accomplish the verification, such as temperature, vacuum, pressure, hydraulic, or pneumatic gages.

4.2.5 Failures that might occur during operation of equipment shall be listed. Troubleshooting data and fault isolation techniques shall state: (a) the indication or symptom of trouble; (b) the instructions necessary, including test hookups, to determine the cause; (c) special tools and equipment; and (d) methods for returning the equipment to operating conditions. Information may be in chart or in tabular format with appropriate headings.

4.2.6 Instructions shall be provided for all removal, repair, adjustment, and replacement procedures. Exploded and sectional views giving details of assemblies shall be provided, as necessary, to clarify the text. For mechanical items, dimensional information with tolerances, clearances, wear limits, maximum bolt-down torques, and in-place balancing or other means of reducing noise level, if required, shall be supplied.

4.2.7 Notes, cautions, and warnings shall be used to emphasize important and critical instructions where necessary. Notes, cautions, and warnings shall immediately precede the applicable instructions, and shall be selected as follows:

NOTE: Concerns an operating procedure or condition which should be highlighted.

CAUTION: Concerns an operating procedure or practice which, if not strictly observed, could result in damage to, or destruction of equipment.

WARNING: Concerns an operating procedure or practice which, if not strictly observed, could result in injury to personnel or loss of life.

4.2.8 Manuals shall contain all illustrations necessary to locate and identify components of operational and maintenance significance. Where necessary for clarity, illustrations shall show configuration and the removal and disassembly of parts. The following types of diagrams shall be included: schematic diagrams which show the arrangement of component devices or parts; wiring diagrams which show the connections of the circuit arrangement; and schematic piping diagrams which show the interconnection of components, of piping, tubing, or hose, and the direction of air flow.

4.2.9 Circuit diagrams for electronic units shall be provided to support maintenance and troubleshooting. Circuit diagrams shall cross-reference repair parts shown in test tables and parts lists. The function name of each stage or circuit, primary signal flow, test points, wave forms with pertinent characteristics, electrical characteristics of parts, name of

each variable control, input and output connectors/terminals voltages and signals shall be specified. Voltage and resistance values measured with controls set for normal operation shall be shown for significant points, such as terminal boards and connectors. Interconnecting cable diagrams shall be furnished to show TO-FROM information, including any intermediate connections. Block diagrams shall be provided to support installation instructions, but shall not be substituted for necessary schematic diagrams.

4.2.10 Parts lists shall provide positive identification of parts necessary for support of the systems or equipment and shall include sufficient information to enable maintenance personnel to requisition replacement parts.

4.2.11 Clear and legible illustrations shall be provided to identify component parts and parts' relationships. Part numbers and part names may be shown on illustrations or separately listed. When the illustrations omit the part numbers and names, both the illustrations and separate listings shall cross-reference illustrated part to listed part.

4.3 Format.

4.3.1 Wherever possible, commercial manuals will be incorporated without change in either content or format. The commercial manuals may be bound without disassembly in the facility manual or may be disassembled and applicable portions incorporated into existing manuals.

4.3.2 The manual may be divided into volumes to prevent the manual from becoming too bulky.

4.3.3 The manual shall be oriented toward operation, maintenance, and repair of the equipment by the operators and maintenance personnel and without the assistance of a manufacturer's representative.

4.3.4 The text shall be specific, concise, and clearly worded to be easily understood by personnel involved in the operation, maintenance, and repair of the equipment.

4.4 Manuscript Review. Draft manuscript copies, in the format and number as specified, shall be provided to the Government for review. (See 4.) Operating and maintenance procedures, including checkout, calibration, alignment, scheduled removal and replacement instructions, and associated checklists shall be validated against the system (or equipment) in the presence of Government personnel.

4.5 Posted Instructions. Besides the operation and maintenance manuals, the following diagrams and instructions shall be furnished and installed, framed under glass or approved plastic laminate, and permanently posted within view of the installed system:

- Complete layout diagram to include all wiring, controls, system components, plumbing, valves, and regulators.
- Selective starting and stopping procedures.

- Checking procedure for normal operation.
- Abbreviated recommended preventive maintenance procedures.
- Emergency instructions.
- Warnings and precautions.

4.6 Field Instructions. After installation, startup, testing, and acceptance of the system, the contractor shall be required to supply the services of a competent representative for not less than 4 h to instruct local maintenance and operating personnel in the proper operation and maintenance of the complete system.

## 5. CONCLUSIONS

This report includes the minimum requirements for central dental high-vacuum (HIVAC) oral evacuation systems and associated centrally plumbed distribution networks for use in USAF dental health facilities. These specifications are interim until joint evaluations by the Dental Investigation Service and the Occupational and Environmental Health Laboratory establish standards for dental clinics. Any questions should be directed to USAFSAM/NGD, Brooks AFB, TX 78235-5301, AUTOVON 240-3502, commercial (512) 536-3502.

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